The US Environmental Protection Agency (EPA) and Arizona Department of Environmental Quality (ADEQ), "The Agencies", are in receipt of your February 10, 2017 letter stating Air Force's (AF's) intention to move forward with implementation of the Enhanced Bioremediation (EBR) work plan for ST12, despite the objections raised in our letter to you dated February 8, 2017 and the January 25, 2017 technical responses sent to Cathy Jerrard. The Agencies understand the AF's desire to move forward with implementation of EBR; however, our technical ~~staff still have~~staff still has concerns about some of the basic information on how EBR will be implemented and evaluated as a viable treatment technology. In order to prevent potential long-term adverse impacts from EBR, the Agencies recommend implementing EBR in a phased approach on limited areas of the Site, using a re-circulation approach similar to that outlined in the approved May 2014 RD/RA work plan. It is necessary to use ~~an~~ a re-circulation approach similar to that outlined in the May 2014 Final Work Plan because that approach was used in the modeling to predict the remedial time frame. The phased implementation must allow the Agencies~~us~~ to verify that benzene (including benzene in the LNAPL phase) is being degraded/depleted, to verify effective TEA distribution throughout the treatment area, and to determine the optimal conditions for EBR.

For this Agencies-recommended phased approach, ~~T~~the AF, with input provided by the regulatory agencies, would select two locations at the Site to implement EBR initially; one location would be in an area of high LNAPL concentration, and another area with dissolved phase contaminants only. We propose that the primary measure of effectiveness of EBR would be reduction of ~~Benzene~~ benzene concentrations in LNAPL and groundwater, after allowing for the potential increase in dissolved phase concentrations immediately after the TEA is injected. Other lines of evidence to demonstrate that EBR is working as expected would include ~~(microbiologist, help me out here – we talked about multiple lines of evidence)~~geochemical and microbiological analyses, listed in the attached document, to determine the response of site geochemistry and the microbiota (particularly those microorganism groups known to be involved in degradation of benzene under sulfate-reducing conditions) to sulfate injection. This eEmpirical data collected before and during implementation of EBR would be used to evaluate its efficacy, ~~and~~ would be the basis for optimizing the system asif appropriate, and would provide data on benzene degradation rates to be incorporated into appropriate models to predict~~ed~~ the time to remediation.

This Agencies-recommended ~~The~~ phased approach would be initiated by pumping from all extraction wells, to establish that the location is ready for EBR injections, as per the ST012 Decision Tree and Criteria for Enhanced Bioremediation, March 2017. An area with no (or minimal) LNAPL recovery (but high groundwater benzene concentrations) and an area of significant LNAPL recovery will be chosen based on pumping results, and the results of the baseline microbial and geochemical data. Each area will have to have a monitoring well approximately half way between the injection and extraction wells. Data to be collected during this time includes: LNAPL volume recovered from each well, LNAPL composition (to track depletion of benzene in the LNAPL, a key component of success for EBR), fluid temperatures, VOCs in groundwater, sulfate concentration, geochemical parameters (including sulfide), and microbial markers, as listed in the attached document. This will provide baseline data against which future data will be compared as a line of evidence for~~of~~ the effectiveness of the EBR

Commented [WU1]: Do we have any strong evidence that long term adverse effects could happen (i.e., actual experience at some site)? If not, we probably should leave this part out, since AF would probably seize on it to divert the discussion from the main points of this document.

Commented [WU2]: Not sure why this would be so. Aren't we going to require that they do actual "predictive modeling" to get a better estimate of remedial time frame (i.e., the "appropriate models to predict the time to remediation" discussed below)? In that case, the AF's earlier "non-predictive" modeling would be outdated and irrelevant for remedial timeframe estimation, wouldn't it, and therefore could not serve as a reason to do recirculation?

Commented [WU3]: I write "this Agencies-recommended phased approach" because AF already plans a phased approach of their own.

Commented [WU4]: Would all the vertical zones at each location be part of the pilot test – or just one vertical zone at each location?

Commented [WU5]: I say "listed in the attached document" because the list of geochemical/microbiological analyses provided by Eleanor is too long to just paste into this document.

Or maybe we could just go with something like I've written here (i.e., without an attached list of analyses), and negotiate later with AF on the exact list.

Commented [WU6]: Need to explain what microbial and geochemical data results would lead to choosing or rejecting an area for this pilot test.

Also, do we want to run the pilot test only in areas where sulfate reduction is shown to be active? Or, are we interested I areas where sulfate reduction is not (apparently) active, to see if sulfate injection can stimulate sulfate reduction?

I suggest that the pilot test focus on areas where sulfate reduction appears to be active.

implementation plan as proposed by AF. This baseline data will also allow us to determine if bioaugmentation is necessary for EBR to be effective.

To initiate EBR, sulfate will be injected at 20 percent of the solubility limit of sulfate (May 2014 Final Work Plan, page 3-17). Flow rates for each of the hydrogeologic zones should be as specified in the May 2014 Final Work Plan. Injection and re-circulation to provide containment should continue for approximately 1 – 1.5 years, while groundwater, LNAPL composition, geochemical, and microbial population data are collected at monthly? bimonthly? intervals. This empirical data will be assessed using multiple lines of evidence to evaluate trends in the data and degradation rates of benzene, that can then be used to update the model (and incorporated into other predictive models) to evaluate the remedial time frame based on the site specific data. Based on the results of these modeling efforts, a decision can be made on whether ~~or not~~ EBR can meet the remedial objectives within the desired time frame. This will also allow us to evaluate potential operational problems, such as biofouling of wells, and methods to alleviate the problems.

Commented [WU7]: Is this proposed time period just for injection/recirculation, or the entire length of the pilot test?

In general (though it may not need to be brought up in this document), I would suggest just adding more areas to the pilot test to expand across the Site as incoming data indicates (or not!) the effectiveness of EBR, and provides information for operational tweaking.

Commented [WU8]: I would suggest monthly for the groundwater, LNAPL composition, and geochemical data, until the injection footprint shows up in the extraction wells. Then quarterly thereafter.

Commented [WU9]: Injection and extraction rates for each well should be monitored to help evaluate fouling.

Note that continual recirculation is an excellent way to encourage fouling.